A multilevel analysis of the effects of external rewards on elementary students' motivation, engagement and learning in an educational game

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- Research Assistants: Ellen Jameson, Steven Zuiker, Adam Ingram-Goble, Eun Ju Kwon
- Teacher: Jake Summers

Participatory Assessment Design Principles

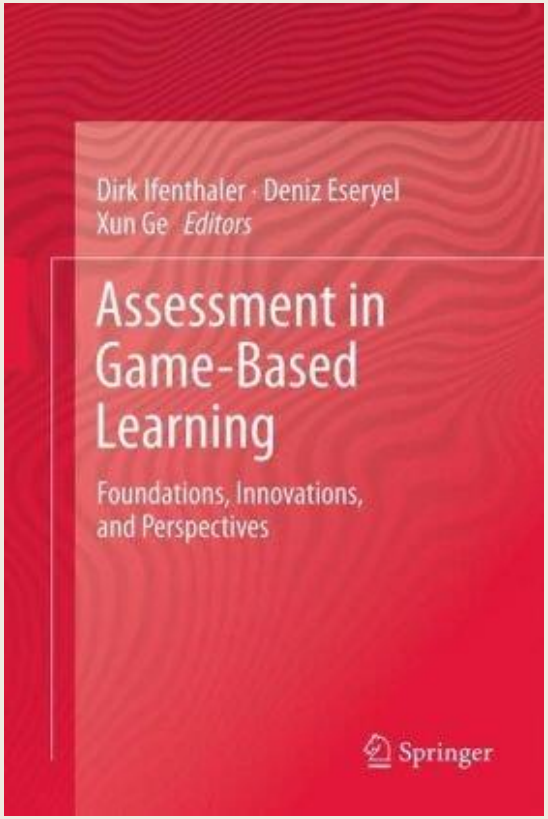
Let contexts give meaning to conceptual tools

Reward disciplinary engagement

Grade reflections rather than artifacts

Assess individual understanding prudently

Measure aggregated achievement discreetly

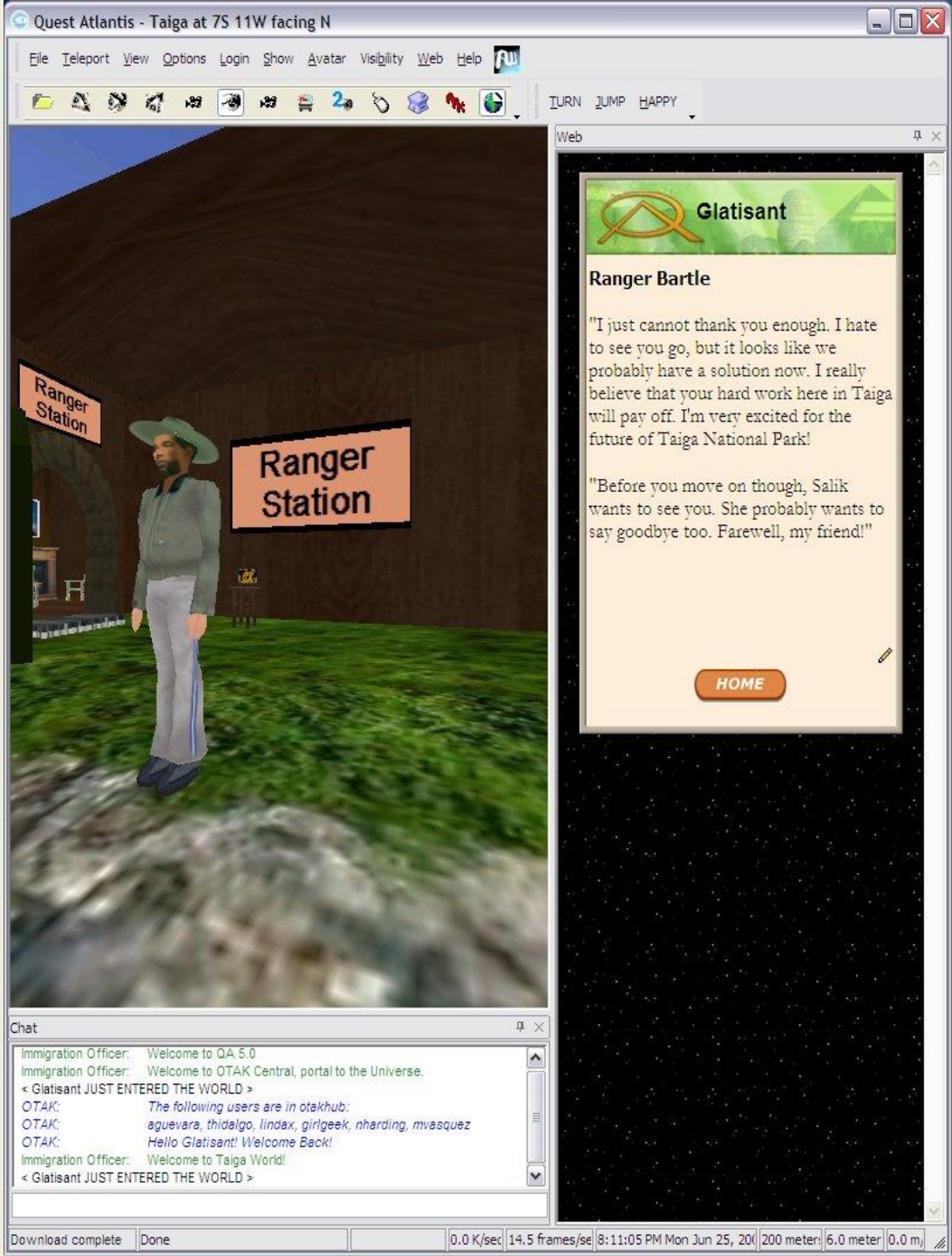


Taiga Ecological Sciences Curriculum

- 13 hours of grade 4-6 curriculum:
  - Ecology (e.g., erosion and eutrophication).
  - Chemistry (e.g., dissolved oxygen).
  - Scientific and socio-scientific inquiry.

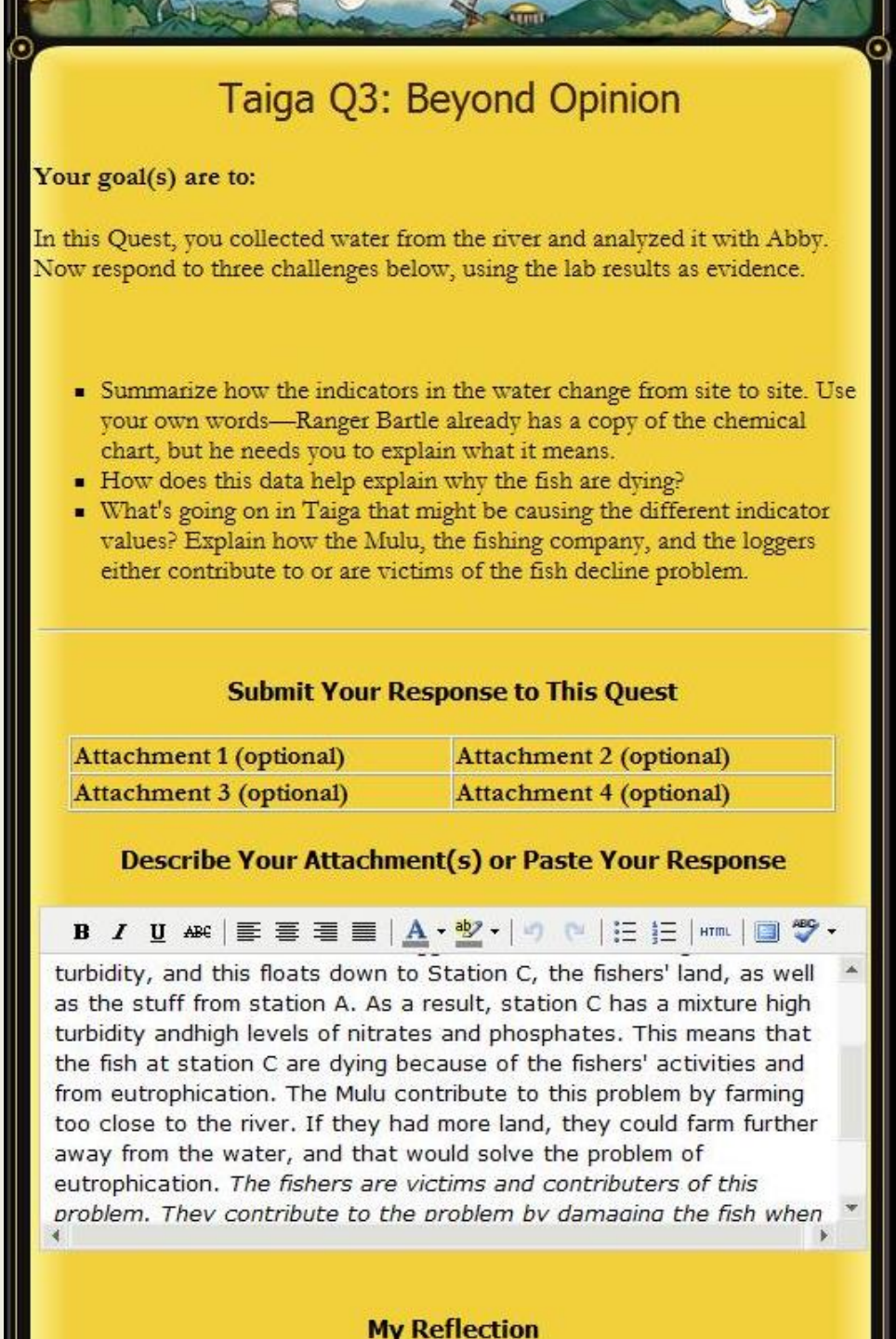
Taiga Challenge

- Assist Ranger Bartle
- Why are the fish dying?
  - Interview NPCs (non-player characters).
  - Take and analyze water quality samples.
- Balance needs of diverse users
  - Sportfishers, loggers, farmers, and visitors
  - Can’t blame one group
  - Support both scientific and socioscientific Inquiry



Example Quest

- Why fish are dying?
  - Interpret indicators (e.g., pH, turbidity)
  - Understand processes (e.g., eutrophication)
  - Coordinate data and theory
- Submit for review by teacher (as Ranger)
  - Revise and resubmit for learning



Taiga Q3: Beyond Opinion

Your goal(s) are to:

In this Quest, you collected water from the river and analyzed it with Abby. Now respond to three challenges below, using the lab results as evidence.

- Summarize how the indicators in the water change from site to site. Use your own words—Ranger Bartle already has a copy of the chemical chart, but he needs you to explain what it means.
- How does this data help explain why the fish are dying?
- What's going on in Taiga that might be causing the different indicator values? Explain how the Mulu, the fishing company, and the loggers either contribute to or are victims of the fish decline problem.

Submit Your Response to This Quest

Attachment 1 (optional)	Attachment 2 (optional)
Attachment 3 (optional)	Attachment 4 (optional)

Describe Your Attachment(s) or Paste Your Response

turbidity, and this floats down to Station C, the fishers' land, as well as the stuff from station A. As a result, station C has a mixture high turbidity andhigh levels of nitrates and phosphates. This means that the fish at station C are dying because of the fishers' activities and from eutrophication. The Mulu contribute to this problem by farming too close to the river. If they had more land, they could farm further away from the water, and that would solve the problem of eutrophication. *The fishers are victims and contributers of this problem. They contribute to the problem by damaging the fish when*

My Reflection

Taiga Assessment by Level

LEVEL (Orientation)	ASSESSMENT	PRIMARY FORMATIVE FUNCTIONS
CLOSE (Activity)	Analyze Content of Quest Submissions	Refine activities, advance learner understanding
PROXIMAL (Curriculum)	Open-ended performance assessment	Guide refinement of the curriculum, formal remediation
DISTAL (Standards)	Randomly selected test items aligned to targeted standards	Convince broad audience of curricular value

Incentives, Competition, Engagement, & Learning

- 30-year debate over extrinsic incentives
- Incentives used in most games that get played
- Current studies on motivation and gaming
  - Correlate self-_____ and learning or measure gains in self-_____
- Hickey (2003, *Elementary School Journal,* after Collins, Brown, & Duguid, 1989) suggested incentives and competition might not be inherently negative.
- Hickey & Schafer (2006, *Handbook* of) laid out a three level model
  - Close engagement
  - Proximal understanding & situational interest
  - Distal achievement and personal interest

Feedback and Learning

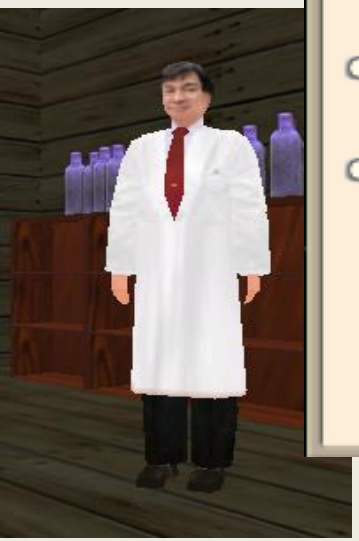
- Feedback is essential in learning environments
  - Supports continued engagement.
  - Don't need to prove feedback "works."
- Feedback on engagement in academic setting usually requires assessment.
  - Formal assessment interrupts experience.
  - Presents crucial balancing act
- Feedback must be useful *and* used:
  - Must consider timing, target, and form.

QUEST ATLANTIS: TAIGA QUEST 2 - BEYOND OPINION
SCORING AND FEEDBACK RUBRIC

Overview	**Instructions**
Use this rubric to review Quest 2 submissions and provide formative feedback. A "complete" submission will show understanding of both water quality *indicators* and ecological *process,* and how they work in *synthesis*. Few submissions are likely to be complete. Students whose submissions are not judged complete need to visit the lab technician who will review these concepts before students resubmit Quest 2.	1. Before using rubric, review the knowledge tables and example responses in the appendix. 2. Review each submission for evidence of the three types of understanding using the rubric below. 3. Assign from 0 to 3 points to each submission. 4. Accept submissions judged *complete* (3 points) and reject others. 5. Cut and paste the corresponding feedback into the feedback submission box.

	1. Indicators	**2. Ecological Processes**	**3. Synthesis**	**Teacher Feedback (Copy and paste it as *Reviewer Comments and Feedback*)**
	Do they understand the various water quality indicators?	Do they understand erosion and eutrophication?	Do they understand how indicators and processes interact?	
	Requires accurate and detailed description of the changes in indicators along the river.	Requires accurate characterization both processes.	Requires accurate integration evidence and processes	
3 Complete	**Yes**	**Yes**	**Yes**	Hi! This is Ranger Bartle. Really great job on this Quest! Your understanding of the chemical indicators and their relation to water quality has really brought us closer to figuring out what is happening in Taiga. You are quite a field investigator. Thank you so much for your hard work and thorough analysis.
2 Near-Complete	**Yes**	**Yes**		Hi! This is Ranger Bartle. Thank you so much for your help on this Quest, but I cannot still understand what is causing the fish decline. I want you to revise this Quest. The Lab Technician has volunteered to help you out. Before revising, you **must** visit the Lab Technician, and talk with him about **how you can use the indicators as scientific evidence of changes in an ecosystem**. You need this to revise your Quest.
1 Partial	**Yes**			Hi! This is Ranger Bartle. Thank you so much for your help on this Quest, but I cannot still understand what is causing the fish decline. I want you to revise this Quest. The Lab Technician has volunteered to help you out. Before revising, you **must** visit the Lab Technician, and talk with him about **what erosion and eutrophication mean** and **how you can use the indicators as scientific evidence of changes in an ecosystem**. You need this to revise your Quest.
0 Incomplete				Hi! This is Ranger Bartle. Thank you so much for your help on this Quest, but I cannot still understand what is causing the fish decline. I want you to revise this Quest. The Lab Technician has volunteered to help you out. Before revising, you **must** visit the Lab Technician, and talk with him about how **indicators are changing along the Taiga River**, **what erosion and eutrophication mean** and **how you can use the indicators as scientific evidence of changes in an ecosystem**. You need this to revise your Quest.

New Formative Feedback Routine



Glatisant

Lab Technician

"Hello! I've had some experience with water quality analysis that you might find very helpful. I'll be happy to share with you what I know. I know we've already talked about the water quality indicators you measured, like pH and turbidity. Are you sure you know what they mean, or would you like to go over them briefly?"

- Yes, I know what the water quality indicators mean.
- No, I'd like to talk about the water quality indicators

HOME

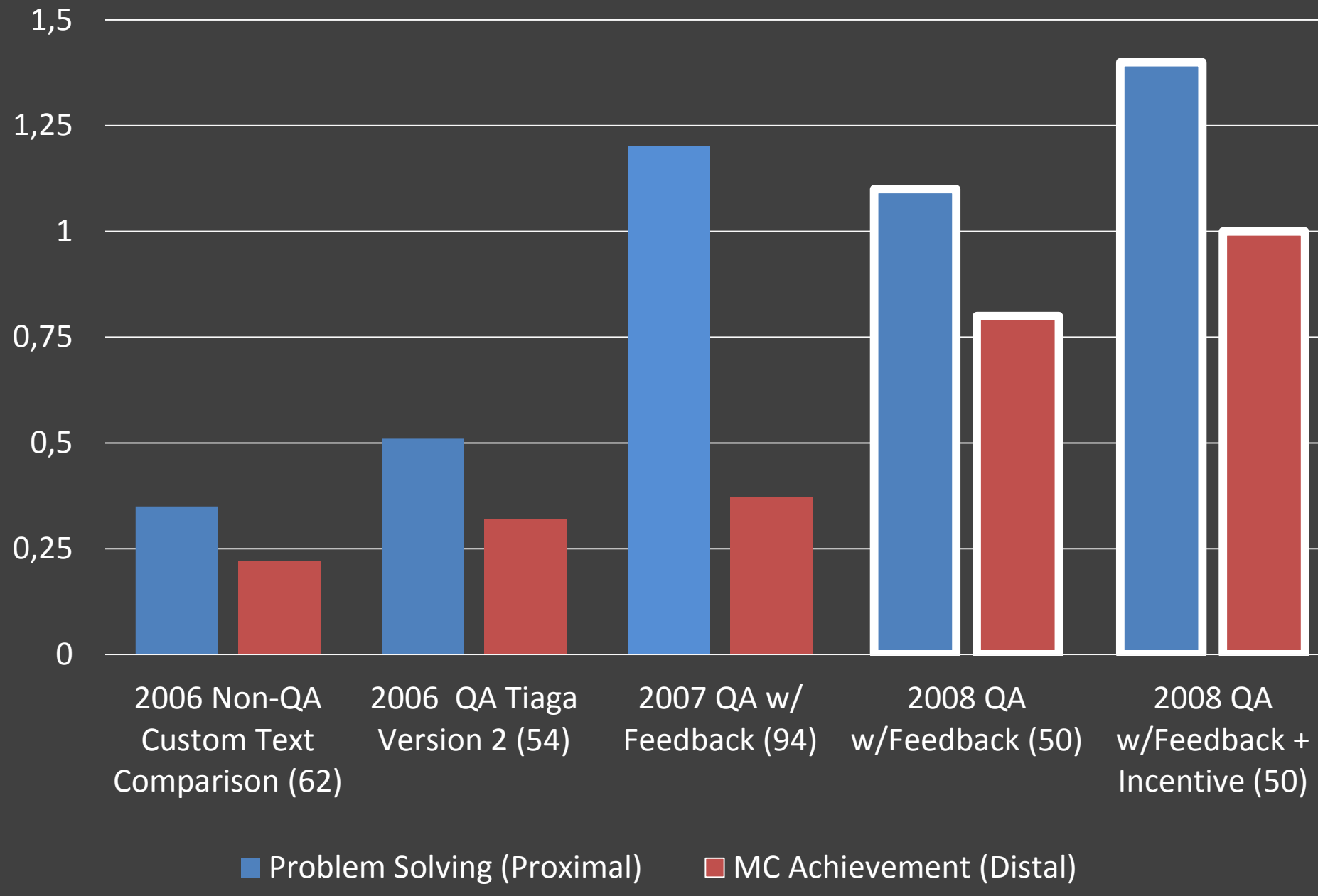
CLOSE [X]

Chemical indicator	Results (A)	Results (B)	Results (C)	Sources and description
pH	6.6	7.0	7.3	A pH of 6.5 to 7.5 is usually very good. Less than 5.5 and greater than 8.5 is usually bad for aquatic life. (Read More)
DO	5.5 ppm	4.5 ppm	4.0 ppm	Dissolved oxygen levels between 5 and 6 parts per million (ppm) are usually needed for are large fish to thrive. Levels below 3 ppm are very stressful to aquatic life.(Read More)
turbidity	6 NTU	27 NTU	22 NTU	Turbidity values of 5 NTU (turbidity units) or less are excellent for many freshwater fish. Values greater than 25 NTU are bad for most fish.(Read More)
nitrates	3.15 ppm	0.96 ppm	2.08 ppm	Nitrate values less than 0.3 ppm are excellent and nitrate values greater than 2.0 ppm are poor. (Read More)
phosphates	3.6 ppm	1.70 ppm	3.08 ppm	Phosphate values less than 0.1 ppm are excellent and phosphate values greater than 3.0 ppm are poor.(Read More)
temperature	17.5 C	22.5 C	22.0 C	If the temperature in a waterway from one location to another changes more than 5 C, aquatic life can become very stressed. (Read More)

Lab Technician

"Please help me to review how the indicators change along Taiga River. Let me know if I am wrong. So in site C near the K-fly Fishing Company, DO, nitrate, turbidity, phosphates are in the unhealthy range for fish. Near the Mulu village,

Learning Gains Across Implementations (in SD)



Challenges to Studying Incentives in Immersive Contexts with DBR

- Individual game and social Game
  - Most motivation and assessment studies embrace an aggregative reconciliation
  - Assessment model embraces a dialectical reconciliation .
- Embedding quasi-experiments in DBR
- Experimental studies of consequential incentives
  - Most important incentives of all

2008 Study of Badges & Incentives

- Manipulated public recognition of questing success:
  - Public Recognition w/ badges & leaderboard
  - No Incentive w/ only “intrinsic” incentives
- Refined the formative feedback routine
  - List of 30 FAQs

2008 Incentive Study
Motivation Outcomes & Measures

LEVEL (Orientation)	Outcome	Measure
CLOSE (Activity)	Intentionality during Quest 2 formative feedback	Appropriate use of formalisms in Quest 2
PROXIMAL (Curriculum)	Intrinsic motivation during Quest 2 task	Self-reported motivational state during Quest 2
DISTAL (Standards)	Motivation towards academic content in Taiga.	Gains in self-reported interest and value in solving ecology problems

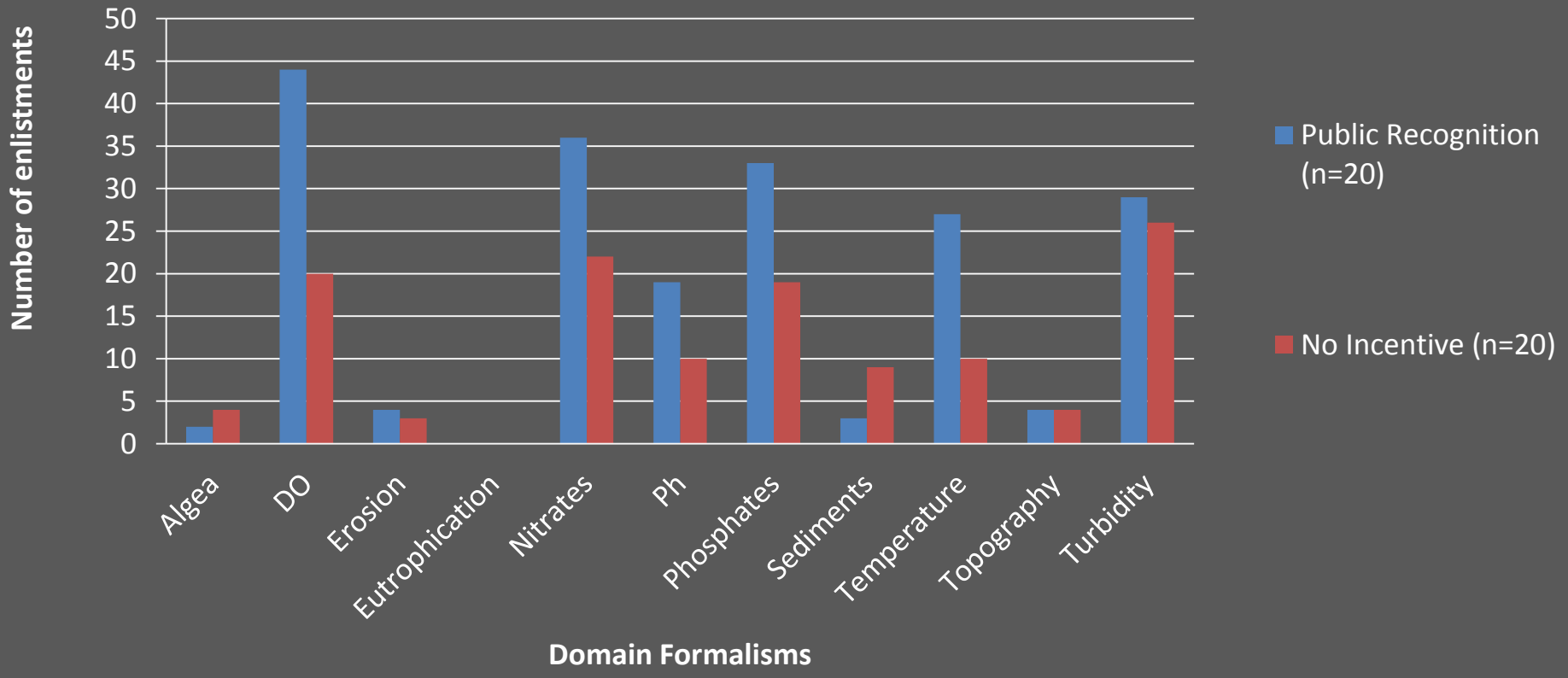
Motivational State Survey (proximal)

Scale (# items)	Example Item	Reliability (alpha)
Interest (5)	**I enjoyed doing Quest 2 very much**	$\alpha = .896$
Value (4)	**I think that doing Quest 2 was useful for learning about water quality (e.g. erosion, Ph, D.O.….)**	$\alpha = .767$
Competence (4)	**I was a pretty skilled at doing Quest 2.**	$\alpha = .781$
Effort (5)	**I put a lot of effort into doing Quest 2.**	$\alpha = .802$

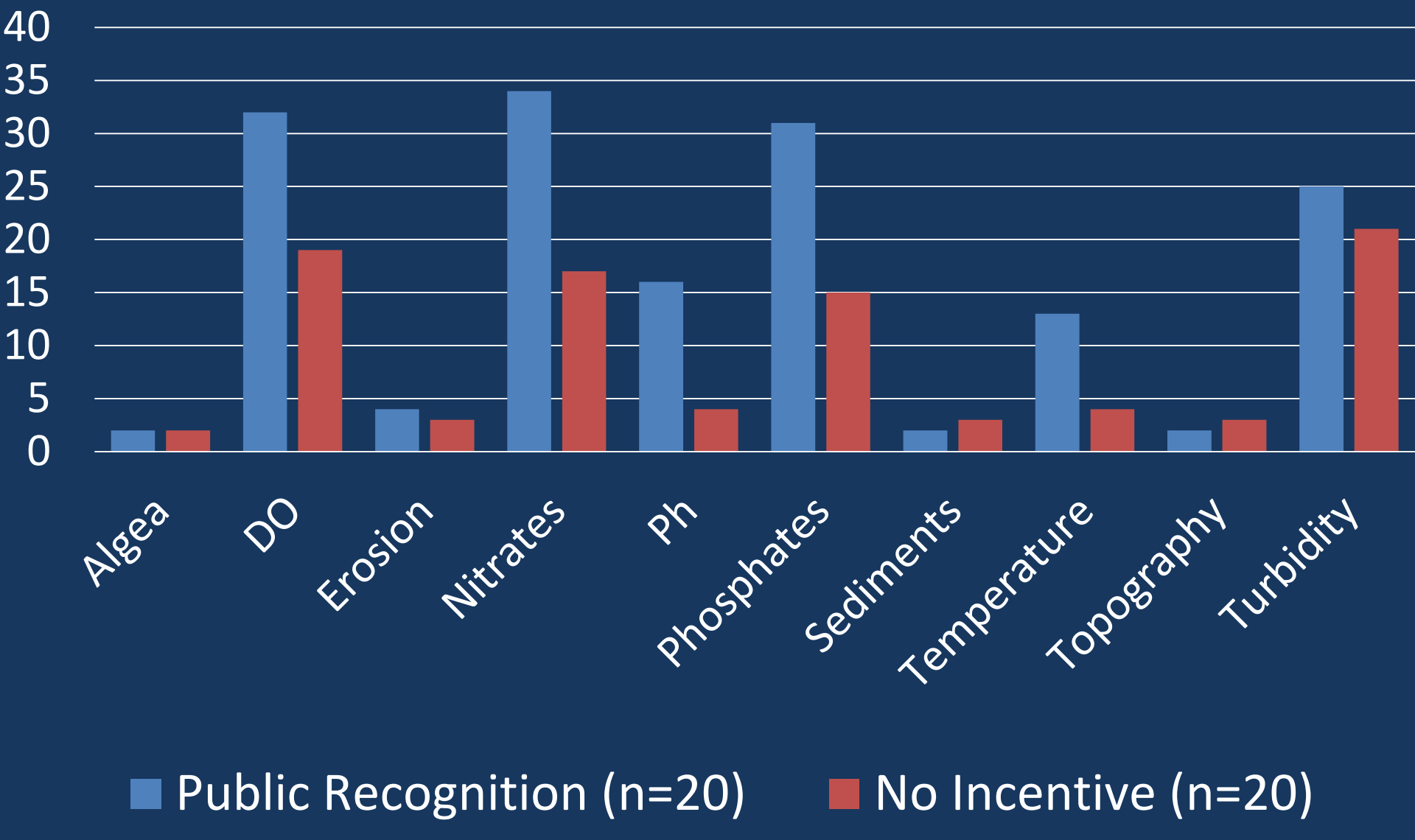
Personal Interest Survey (Distal)

Name (# items)	Stem	Sample Item
Water Quality	**How do you feel about scientific problems involving water quality and ecology (e.g. how fish, river plants and other aquatic life are impacted by development, logging, erosion, watershed damage, etc.)?"**	**3. There is a chance I would take some action (e.g., send an email, collect some data, etc) to help solve water quality problems.**
Complex Science	**How do you feel about scientific problems where the solution to one problem might create other problem (e.g. disposing of nuclear waste, damming a nice river to provide water for agriculture, etc.**	**5. I might choose to read an article in the newspaper about these kinds of problems.**
Contro-versial Science	**"How do you feel about controversial scientific problems that involve complex social, moral, and ethical issues (e.g., genetic engineering, stem cell research, cloning, etc.)**	**4. There are lots of other things that I would rather study than these kinds of problems.**

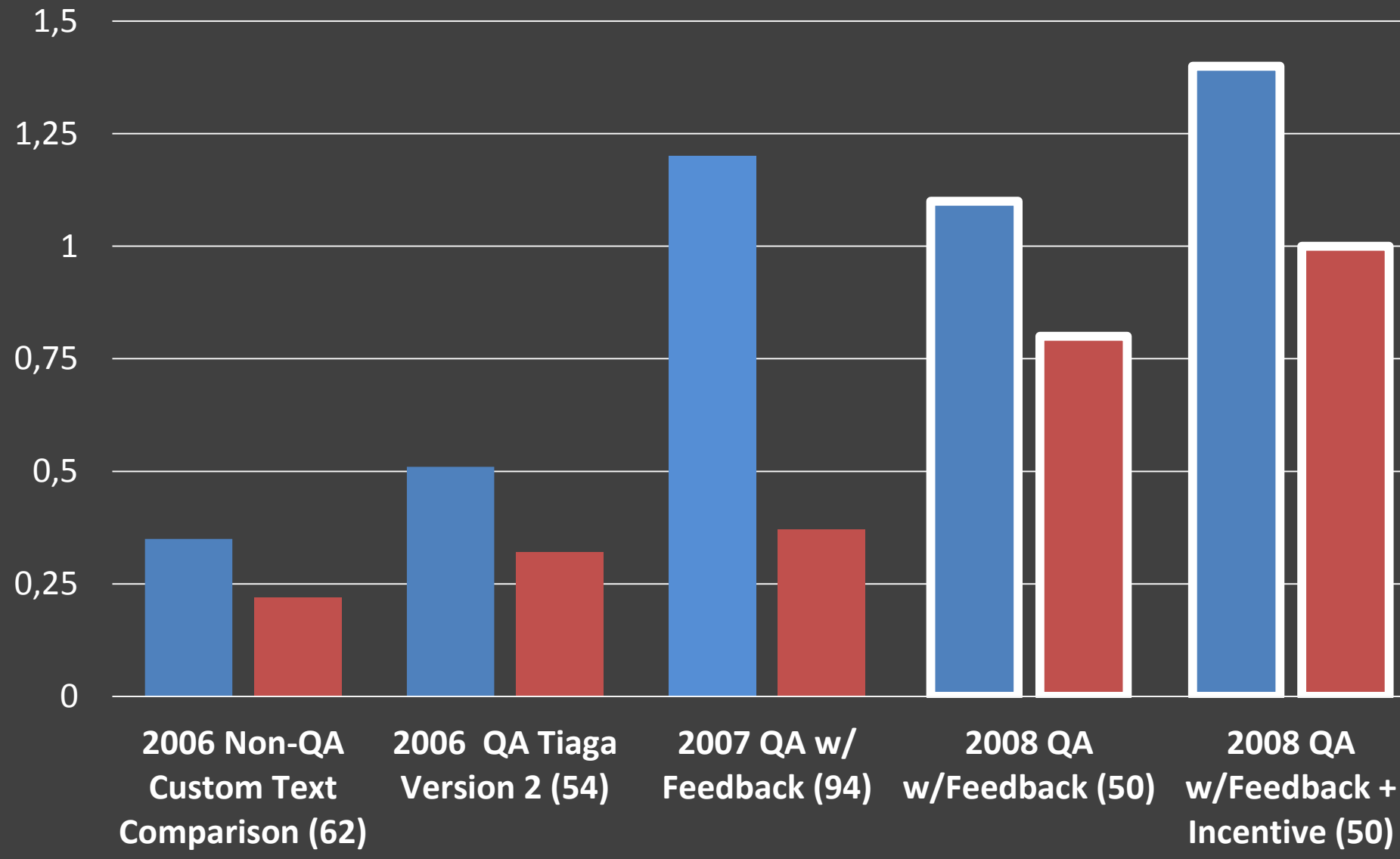
CLOSE ENGAGEMENT & LEARNING
Frequency of Enlisted Formalisms



CLOSE ENGAGEMENT & LEARNING
Frequency of Accurately Enlisted Formalisms



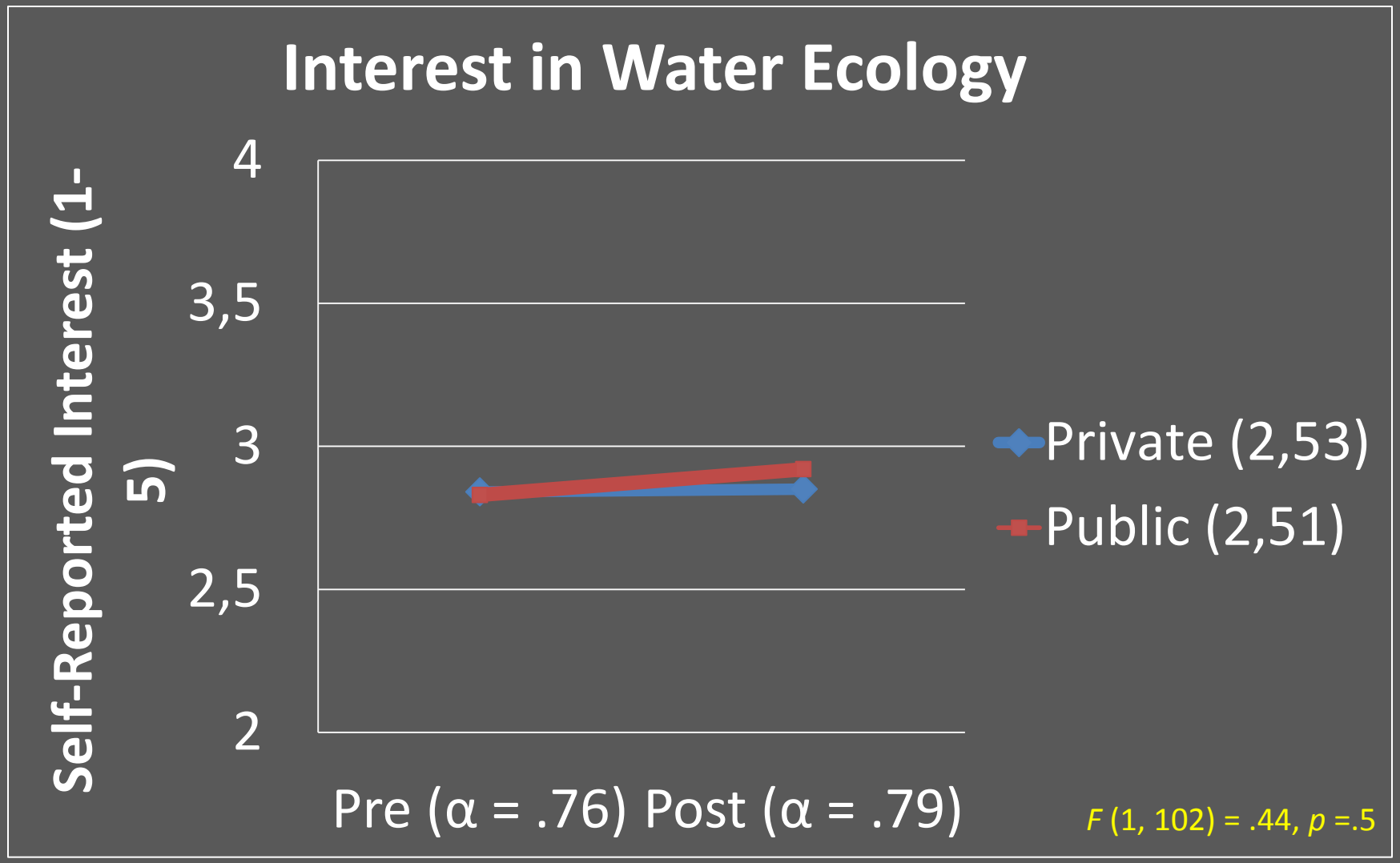
Learning Gains Across Implementations (in SD)



PROXIMAL ENGAGEMENT
Self-Reported Motivational Experience in Quest 2

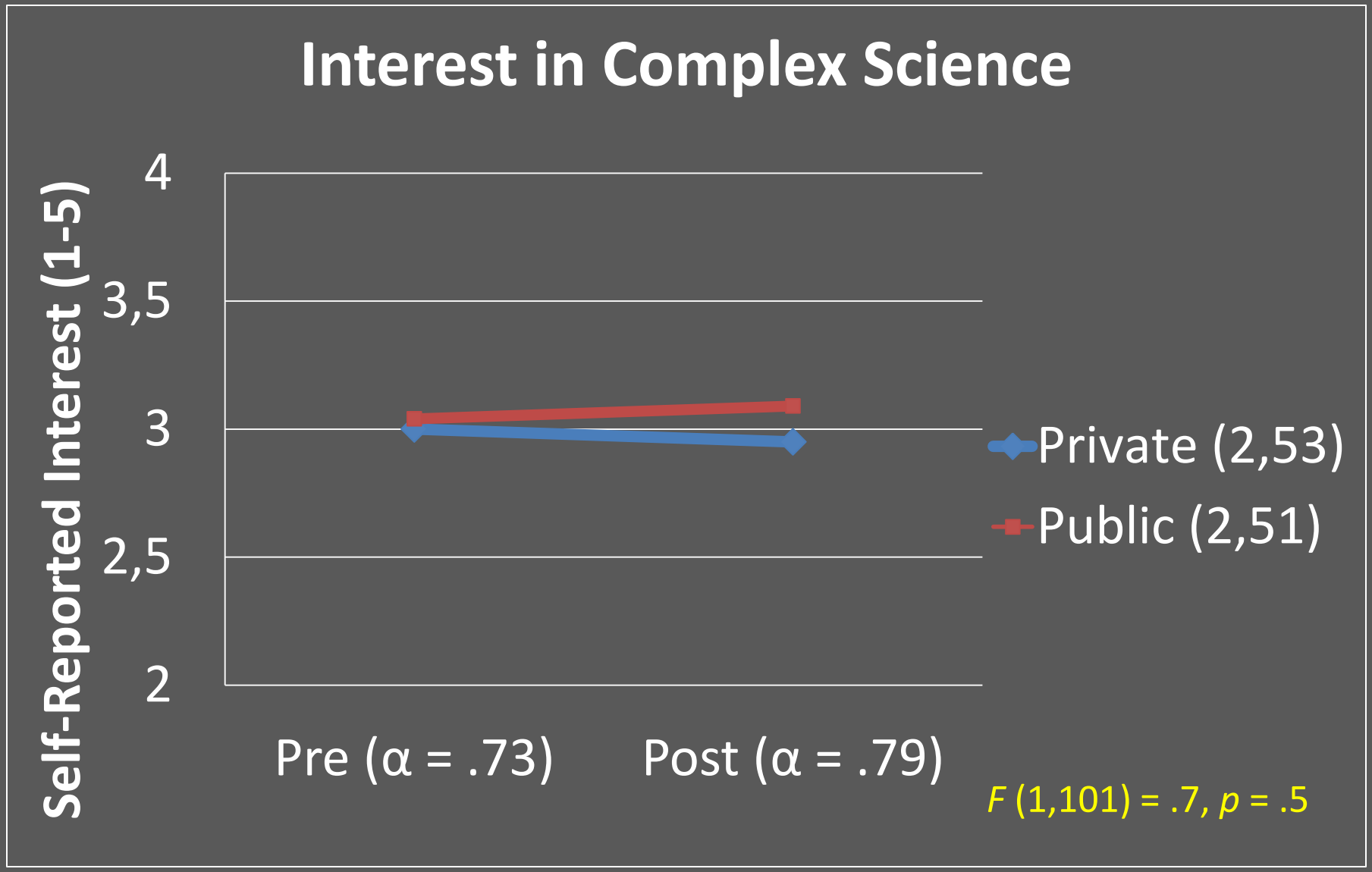
All $F < 1$

DISTAL ENGAGEMENT
Changes in Self-Reported Interest (Ecology)



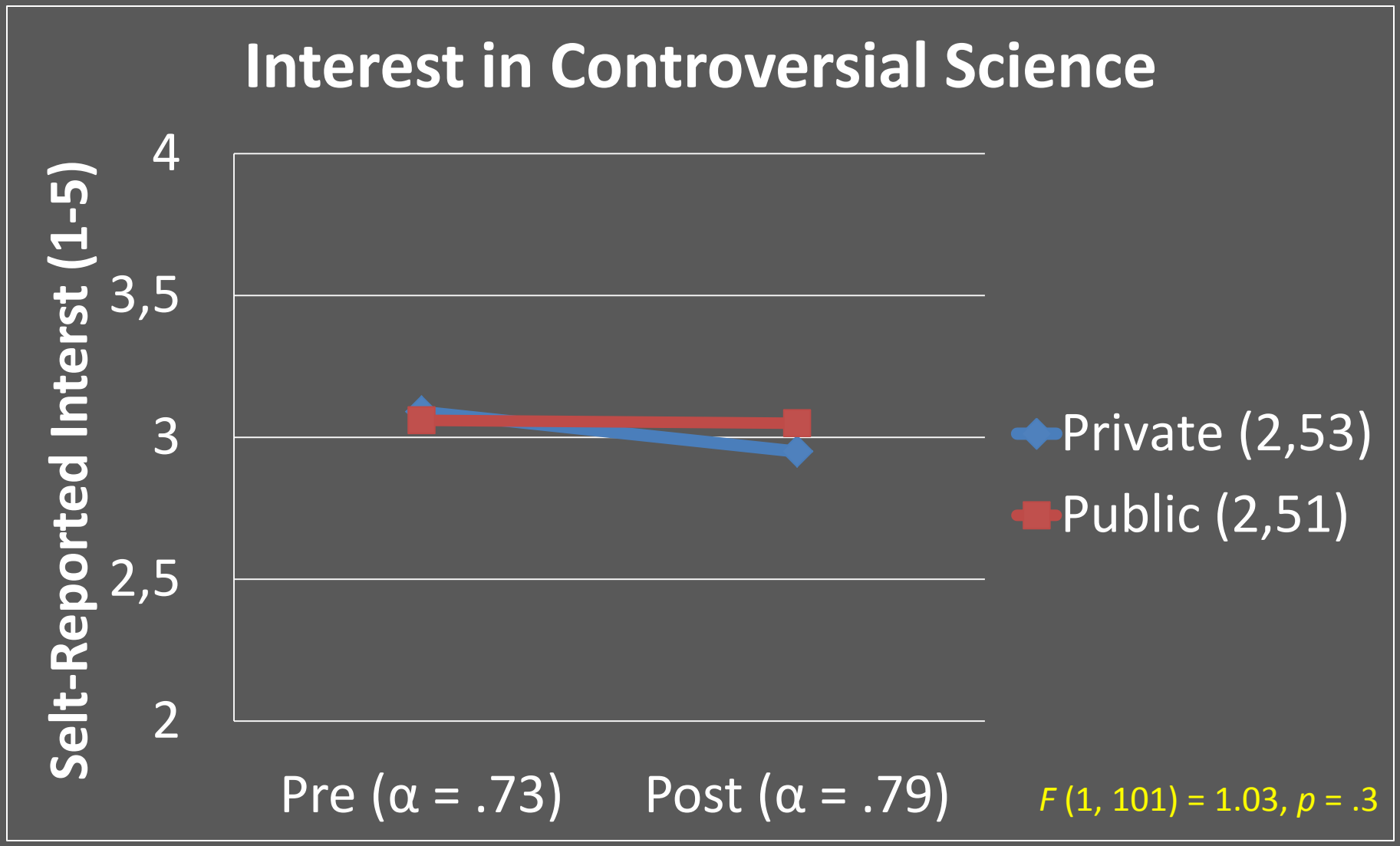
DISTAL ENGAGEMENT

Changes in Self-Reported Interest (Complex Science)



DISTAL ENGAGEMENT

Changes in Self-Reported Interest (Controversial Science)



Summary & Conclusions

- Slight positive impact on disciplinary engagement, cognitive engagement, & interest
- Significant positive impact on proximal understanding and distal achievement
- Supports Collins et al. (1989) and Hickey (2003)
  - Competition seems okay as long as there is feedback and opportunity to improve
  - Seems unlikely that incentives that empower students would also disempower them
- Shows value of DBR and participatory model
- Supports prevailing QA incentive practice

Summary & Conclusions in Filsecker & Hickey (2014)

- No impact on engagement or motivation
- No impact on distal achievement
- Positive impact on proximal understanding

Analysis Issues

- How to relate individual & social
  - Immediate-level analysis of engaged participation
  - Role of teachers, where to go with DBIR
- Engaged participation as motivation
  - The intrinsic/extrinsic dichotomy remains primary
- How do we study consequential incentives?
  - How can incentivizing autonomy undermine autonomy?

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